Sunshine Coast Forest District

Documentation of Vegetation Resources Inventory Preliminary Analysis

PREPARED BY:

MINISTRY OF FORESTS
RESOURCES INVENTORY BRANCH

December 14, 2000

Revised: February 8, 2001

FOREST RENEWAL BC

Acknowledgements

This report was prepared by Resources Inventory Branch staff. We would like to gratefully recognize the contributions made by the following people:

Sunshine Coast Forest District:
Steve Waghorn

Vancouver Region:
Craig Robinson
Jeff Kerley
Roman Bilek
John Markila

Timber Supply Branch:
Chris Fletcher

Resources Inventory Branch analysis team:
Lawrence Bowdige
Rob Drummond
Edward Fong
Gary Johansen
Alf Kivari
Bob Krahn
Colleen McKendry
Sam Otukol
Will Smith
Keith Tudor

Contractors:
Gitte Churlish
Karen Jahraus

Executive Summary

This report documents the Vegetation Resources Inventory (VRI) preliminary analysis that was completed for the Sunshine Coast Inventory Unit in anticipation of the Timber Supply Review (TSR) II in 2000. The report was developed in conjunction with Ministry of Forests staff from Resources Inventory Branch, Timber Supply Branch, the Vancouver Region, and the Sunshine Coast Forest District.

The report references and contains content from the previously developed "Sunshine Coast Forest District Vegetation Resources Inventory Ground Sampling Plan: Revised Final Report, October 1997".

This analysis focussed on the development of adjustment factors for height, age and volume to support the current timber supply analysis. The process used to derive these adjustments is interim and may change in the future.

Based on a population of interest defined as the vegetated, treed portion of the Sunshine Coast forest district, the results indicated an overall ground volume to inventory volume ratio of 1.14 ± 0.13. This can be interpreted as indicating that inventory volumes may be underestimated by 14% on average.

The information in this report will be considered by Timber Supply Branch in the timber supply review process.

Table of Contents

Acknowledgements i
Executive Summary ii
Table of Contents iii
1 Introduction 1
1.1 Purpose 1
1.2 Background 1
1.3 Description of the Inventory Unit 2
2 Sample selection based on original ground sampling plan 5
2.1 Data assembly process and database constraints 5
2.2 Data sorting criteria 5
2.3 Sample selection procedure and sample selection issues 7
3 Data Collection 7
3.1 Description of data collection process 7
3.2 Contractors involved in data collection 7
3.3 Description and results of the cruise audit process (Quality Assurance) 8
3.4 Inaccessible samples and remedial measures taken to mitigate the effect of the missing data 9
4 Data editing and cleaning 9
4.1 Data entry and compilation processes 9
4.2 Pre-analysis data editing 9
4.3 Changes to the photo interpreted data between the time of sample selection and analysis 10
5 Statistical adjustment of attributes 10
5.1 Overview 10
5.2 Population for adjustment 11
5.3 Data Source 11
5.4 Data issues related to the analysis 11
5.5 Weighting 12
5.6 Post-stratification 13
5.7 Attributes to be adjusted 13

5.7.1 Age and height 13
5.7.2 Volume 14
5.8 Adjustment methodology 14
5.9 Limitations of the adjustment methodology 15
5.10 Ecological and other timber attributes for which summary statistics will be generated 15
6 Discussion of results 15
6.1 Descriptive sample statistics (before adjustment) 15
6.2 Adjustment coefficients and associated statistics 16
6.2.1 Height and age adjustment 16
6.2.2 Volume adjustment 17
6.3 Evaluation of the results based on target sampling errors 18
7 Comparison of NVAF and loss factor volumes 19
8 Application of results for TSR 19
9 Appendices 21

1 Introduction

1.1 Purpose

This report was assembled to provide a detailed description of the procedures and assumptions that went into the preliminary analysis of the Sunshine Coast TSA Vegetation Resources Inventory data and to document the results to date.

1.2 Background

The primary driver for initiating a Vegetation Resources Inventory project in this management unit was the need for an assessment of the accuracy of the inventory. An inventory audit was not completed in this TSA.

In October of 1997, a Vegetation Resources Inventory Strategic Plan (VSIP) was prepared for the Sunshine Coast TSA[1]. The objective of this strategic plan is to identify forest management issues and methods by which the Vegetation Resources Inventory (VRI) program can address these concerns. Forest management issues in the District included:

- the state of the current inventory;
- inaccurate individual polygon descriptions, especially for deciduous forest types, urban areas, and private land;
- site productivity of second growth and old-growth site index;
- inaccurate loss factors;
- criterion indicators
- incidence of root rot and other forest health issues;
- identification of non-timber resources; and,
- quantification of wildlife related attributes.

The area considered in the VSIP covered the entire landbase within the administrative boundaries of the District, including TSA, TFL, private, park, and reserve land.

The VSIP outlined two primary objectives for data collection. The first objective was to implement VRI Phase II ground sampling over the entire Forest District to provide information to audit the existing timber inventory in the District, and provide a basis for improving the overall accuracy of the inventory. The sampling objective was to achieve a target precision of ± 10% sampling error (95% probability) for timber volume in the treed portion of the District (including the timber harvesting land-base, inoperable land-base, parks and private land).

The second objective was to improve the accuracy of timber net volume and site index in the treed portion of the TSA and the TFLs for the latest timber supply analysis (1999).

---

[1] October 20, 1997. Sunshine Coast Forest District: Vegetation Resources Inventory Ground Sampling Plan Revised Final Report Addendum.

The number of samples would aim to provide target sampling errors of ± 10% (95% probability) for timber volume in the treed portion of each management unit. Each management unit in the District (TSA, and each of the TFLs) was to be treated as a separate sub-unit.

Other ground sampling activities to support the VRI process included: Net Volume Adjustment Factor (NVAF) sampling and Within Polygon Variation (WPV) sampling.

The objective of Net Volume Adjustment Factor (NVAF) sampling was to improve estimates of tree net volume from the net factoring process. This is accomplished using stem analysis to provide local estimates of decay and tree taper. The data from stem analyses are used to develop a factor (NVAF) to adjust the net volume from the Phase II ground sampling (derived from the net factoring process and taper equations). The basis for the method used to calculate the NVAF, is the estimation of the actual net volume of felled trees. The NVAF sampling unit is the tree. The attributes of interest are actual merchantable volume per tree and actual percent sound wood of the merchantable volume. A total of 200 sample trees in at least 30 sampling points was initially recommended for sampling.

The original VSIP recommended a total of 205 ground sample plots be established, 130 of which were to collect full VRI data and 75 of which were to collect timber emphasis data only. The sample size was determined to provide a 10% sampling error for net volume at the 95% level of probability for the entire vegetated and non-vegetated landbase in the District.

For the 1997 field season, 35 VRI sample plots were planned in the Sunshine Coast District. After these samples had been collected, the stakeholders reassessed the business needs in the District and revised the ground sampling plan. Under this revised plan, an additional 35 VRI samples were to be established in the district[2], bringing the total number of VRI samples to 70. The remaining sampling resources were shifted to focus on timber emphasis (TEP) samples installed in the vegetated, treed portion of the TSA[3]. The number of timber emphasis samples in the TSA was increased to 120. In addition, the samples in this study were to selected such that approximately 80% would come from operable areas and 20% from inoperable areas.

1.3 Description of the Inventory Unit

The inventory unit for the Sunshine Coast Vegetation Resources Inventory (VRI) is the entire landbase within the administrative boundaries of the District including the TSA, TFLs, private land and parks. The Sunshine Coast TSA is located along the southwest coast of British Columbia and covers approximately 1.2 million ha. The TSA is within the Southern Pacific Ranges of the Coastal Mountains and extends from Howe Sound

[2] The installation of the 70 full VRI samples across the entire Sunshine Coast District was referred to as the DSC1 project.

[3] The installation of 120 timber emphasis samples in the vegetated, treed portion of the TSA was referred to as the DSC2 project.

north to Bute Inlet in the Vancouver Forest Region (Figure 1). Parts of TFLs 39, TFL 43, and all of TFL 10 are within the Sunshine Coast Forest District (Figure 2).

Figure 1: The Sunshine Coast Forest District in the Vancouver Forest Region.

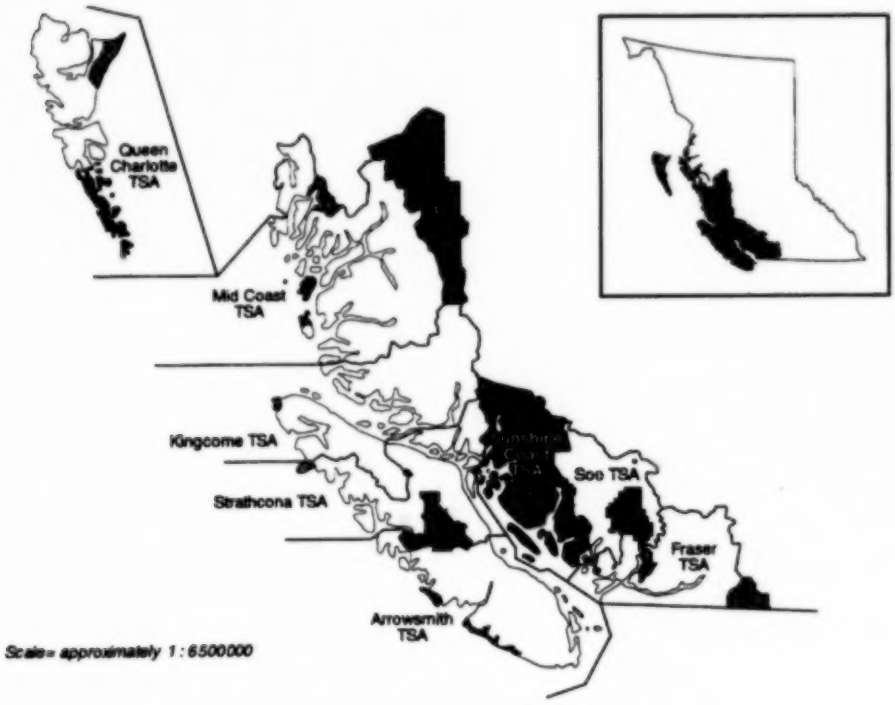


Figure 2: Area within the Sunshine Coast Forest District.

2 Sample selection based on original ground sampling plan

2.1 Data assembly process and database constraints

Data assembly was initiated in 1997 with Resources Inventory Branch staff creating the project database by collecting all Forest Inventory Program (FIP) and Forest Cover (FC1) files for the Sunshine Coast district. The data in these files were all in NAD 27. All files were merged into one spatially correct, Geographic Information System (GIS) database using PAMAP software.

Other database corrections were made to address split polygons. These occurred after appropriate overlays (e.g. BEC, ownership) were applied to the forest cover polygons. Where forest cover polygons were split, overlay attributes (e.g. BEC information layer) were assigned to all split polygons based on those attributes that coincided with the largest portion of the original forest cover polygon.

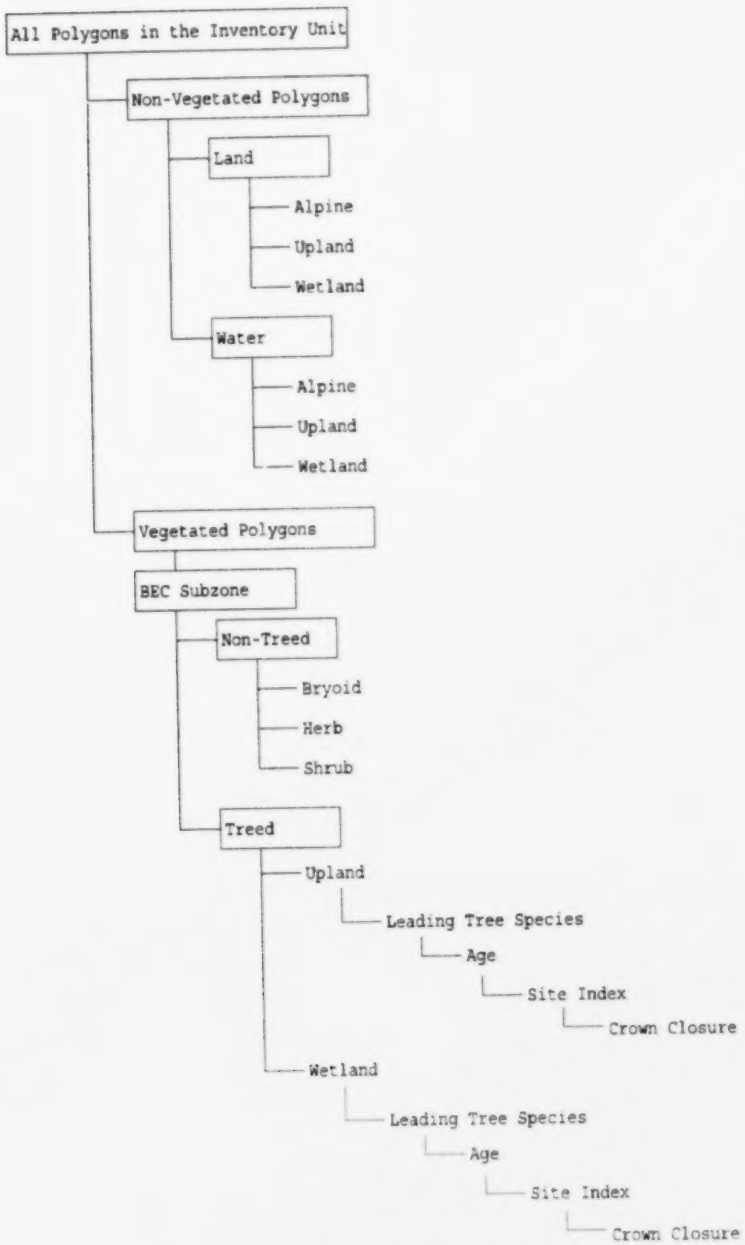
The database contained physical operability information. Polygons were assigned an operability code[4] based on majority area (i.e. >50%). Since the timber emphasis samples were to be installed within the TSA only, TFL land had to be identified in the database. TFL 10 and TFL 39 were clearly distinguished in the database however TFL 43 was not. Polygons in this management unit were individually identified and tagged after the sampling took place.

2.2 Data sorting criteria

The objective was to sort the spatial database hierarchically by land cover classification for vegetated versus non-vegetated polygons, and then further within the vegetated classification by treed and non-treed. Within the vegetated-treed (VT) classification, further sorting was done based on leading species, projected age, site index and crown closure (re: Figure 3).

[4] Operability was coded as A (accessible), C (helicopter accessible), I (inaccessible) or N (unknown). Polygons with either codes A or C were considered to be "operable".

Figure 3: Standard polygon sort criteria for Vegetation Resources Inventory ground sampling.



2.3 Sample selection procedure and sample selection issues

The revised VRI ground sampling plan for the Sunshine Coast inventory unit specified a total of 190 ground samples. 70 full VRI samples were to be selected from throughout the district. The remaining 120 TEP samples were to be located in the vegetated, tree (VT) portion of the TSA, with approximately 80% falling in operable areas and 20% in inoperable areas.

The process to select the required ground samples was to first systematically draw 10,000 potential samples from the sorted list that includes all polygons in the district. A 500 subsample dataset was then used for the selection. The 70 full VRI samples were systematically selected from this list.

The same 500 subsample dataset was used for the selection of the 120 TEP samples. All samples previously selected for the VRI, all non-vegetated samples, and samples falling in TFLs were removed[5]. The TEPs were then selected systematically from a sorted list (BCLCS, species, age, and site index). 80% of the samples were selected from the operable landbase and 20% from the inoperable landbase.

3 Data Collection

3.1 Description of data collection process

Phase II ground sampling was initiated in 1997 and continued in 1998. One sample that could not be established because of snow was completed in the summer of 1999. The NVAF sampling was completed over the 1998 and 1999 field seasons. Budgetary restrictions did not allow for all of the TEPs in the DSC2 study to be established. Additional sampling for the DSC1 project (full VRI across the entire district) is currently on hold until further funding is made available. Completion of the timber emphasis sampling in the TSA is dependent on the statistical results from sample data collected to date, available funding, and district objectives. All data was collected according to VRI standards for timber, full VRI and coarse woody debris.

3.2 Contractors involved in data collection

VRI certified crews were used to collect the data following the appropriate VRI *Ground Sampling Manual*. Four forest contracting firms carried out the ground sampling in the 1997 and 1998 field seasons: Simons Reid Collins, R.G. McCreedy, Dale McLean & Associates and VGI Consulting. The NVAF sampling in 1998 and 1999 was carried out by Sylvametrics.

[5] TFL 43 was not initially identified in the database. As a result, TFL 43 polygons were not excluded from the sample selection dataset. One of the samples was identified as being in TFL 43 after establishment and was removed prior to analysis of the TSA data.

3.3 Description and results of the cruise audit process (Quality Assurance)

The cruise audit process assessed the quality of the field sampling data collection. A target measurement error of +/- 10% for gross volume (when ground volumes were compared with audited ground volumes) was set for the project. This level of acceptable measurement error provides some indication for the forest manager using the data, of the possible range of values around the gross volume.

1997:

In 1997, only full VRI plots were sampled as part of the DSC1 project. Quality assurance (QA) was carried out for 4 full VRI plots from project DSC1 using a contract and Ministry of Forests crew. One sample was found to be located in the wrong polygon because of a difficult tie point (this was later confirmed with GPS data) and the batch of samples had to be checked/redone. On a second check, all samples passed.

The most notable errors detected during the QA were:
a) mislocation of a sample outside of the target polygon – which was corrected;
b) confusion on the Random Tree procedures. In a couple of cases, crews were leaving the sample without a Random Tree collected. This was cleared up for the 1998 field season.

Other comments of note were that the 1997 field season revealed that the ecology data collection of the full VRI sample was taking too long to complete in the field and the procedures were modified for the 1998 season to speed up data collection.

1998:

Quality assurance was carried out in 1998 for the 120 samples established as either full VRI samples (from the DSC1 project) or Timber Emphasis + BEC (from the DSC2 project). All QA was done by Ministry of Forests staff.

Sixteen samples were checked and the majority were well done. The sixteen QA samples checked were the following:

13 full checks "Timber Emphasis + BEC" plots from DSC2

2 full checks of "full VRI plots" from DSC1

1 full check of a VRI plot with NVAF enhancements

One batch was failed when the tree count in the check plot was below standard. The batch was redone and rechecked and passed. Other issues that came up were:

a) improper tallying of dead trees in auxiliary plots by a new cruiser - training was done and the problem corrected;

b) data entered into the wrong columns on some ecology cards.

1999:

All the Net-Volume Adjustment Factor (NVAF) sampling was done in late-1998 and early 1999. In 1999, 2 NVAF sample locations were audited and the sample work was well done and passed.

3.4 Inaccessible samples and remedial measures taken to mitigate the effect of the missing data

A number of samples could not be established as originally planned. For the DSC1 study, 15 samples could not be established in their original location. Of these, 2 were replaced by relocating the sample within the same polygon and one was replaced with a new polygon[6]. For the DSC2 study, 25 samples were not established. Of these, one sample was replaced by relocating the sample within the same polygon; 2 were replaced with new polygons[7]. Note that for 12 of these 25 samples, establishment was not even attempted due to budgetary restrictions. These 12 not sampled were selected carefully so as not to introduce potential biases into the final results. For details of the sample establishment, refer to Appendix A-1.

4 Data editing and cleaning

4.1 Data entry and compilation processes

A total of 156 samples were established in the DSC1 and DSC2 projects[8]. Ground sample data was entered using the VRI data entry tool and validated in the VRI Oracle database. An ascii flat file from the database was provided for compilation in the VRI compiler.

4.2 Pre-analysis data editing

The data was checked for inconsistencies and individual samples were examined in detail as required (see Appendix A-2). The following data issues were identified and corrected:

- A keypunch error was identified for sample DSC2-0092. The correction was made in the Oracle database and the ascii file provided for compilation.

---

[6] DSC1-0067/mapsheet 092F068/polygon 218: private land – access denied; relocated to TSA (same polygon)

DSC1-0069/mapsheet 092F098/polygon 1005: dropped due to danger; relocated within same polygon

DSC1-0053/mapsheet 092K025/polygon 149: private land – access denied; relocated to TSA in mapsheet 092K025/polygon 506

[7] DSC2-0010/mapsheet 092F097/polygon 507: private land – access denied; relocated to TSA in mapsheet 092F098/polygon 342

DSC2-0044/mapsheet 92F078/poly 457: private land – access denied; relocated to MB private land in mapsheet 92F088/poly 11

DSC2-0100/mapsheet 92G052/poly 645: private land – access denied; relocated to TSA (same polygon)

[8] The analysis described in this document focuses on the vegetated, treed portion of the TSA. Of the total 156 samples established, 111 samples met these population criteria. The DSC1 project contributed 23 samples and the DSC2 project contributed 88 samples. The 45 samples outside of this population will be available for future district-wide analyses.

- Sample DSC2-0006 was logged after the last update of the inventory for depletions. Hence the logging in this polygon was not reflected in the current inventory data. The BCLCS code for this polygon was changed from vegetated, treed (VT) to vegetated, non-treed (VN).
- Sample DSC2-0004 was originally identified as being within the TSA but was subsequently found to be within the boundaries of TFL 43. The management unit designation for this sample was corrected.

A number of data assumptions were also made that directly related to the analysis of the data. These are discussed in section 5.4.

4.3 Changes to the photo interpreted data between the time of sample selection and analysis

The inventory attributes for this analysis were based on the FIP file data assembled for the original sample selection. It was originally intended that a comparative analysis using the current inventory files would also be completed. However, this was not possible in the time frame available.

All analysis presented in this document was based on the inventory file at the time of sample selection.

5 Statistical adjustment of attributes

5.1 Overview

The analysis of the Sunshine Coast VRI data used the current approach for adjustment of inventory attributes, referred to as the "Fraser Protocol"[9]. Note that the "Fraser Protocol" is an interim process for satisfying Timber Supply Review (TSR) needs. A more comprehensive and long-term process for adjustment of inventory attributes is under development.

In the "Fraser Protocol", the statistical adjustment of inventory attributes consists of a set of steps and assumptions used to develop and then apply adjustment factors to the FIP file attributes of height and age and the volume predicted using VDYP. The goal of the adjustment is to remove any overall bias in the inventory when compared against the VRI ground data for the attributes that are adjusted.

The steps in this adjustment process are outlined below:

1. Adjust height and age.
2. Based on the adjusted height and age, use VDYP to compute inventory volume.
3. Use the compiled ground volumes to then adjust this "attribute-adjusted" inventory volume.

[9] Ministry of Forests. Fraser TSA: File Adjustment Project. File adjustment recommendations. MOF ORCS 13300-20tsaadjmt. April 15, 1997. 10p.

Details of this process are described in the sections that follow.

5.2 Population for adjustment

The population for adjustment was defined as all vegetated, treed polygons[10] in the Sunshine Coast TSA, including private land and parks. No minimum age criterion was applied. All TFL land was excluded from the population for adjustment.

5.3 Data Source

The inventory data was from the original FIP files used for sample selection, projected to 1998[11].

The inventory file (which used mapsheet and polygon numbers as keys) was linked to the compiled data file (which used cluster identification as key) through a file that provided the complete sample selection list and the corresponding VRI sample number (cluster id), mapsheet, and polygon for each sample[12].

As changes and corrections to the sample data were made, the data was recompiled (see section 5.4 for examples). The final compiled data used in the analysis was provided on October 15, 1999[13].

5.4 Data issues related to the analysis

For the two projects in the Sunshine Coast Forest District, ground data was collected for a total of 156 samples. These included 17 samples that were established within TFLs. Since TFLs are considered outside of the TSA, these 17 samples were excluded from the current analysis. An additional 28 samples within the TSA were either non-vegetated or non-treed. Since these samples did not meet the population criteria of being vegetated, treed and within the TSA they were also excluded from this analysis. After these removals, a total of 111 samples remained in the analysis population.

There were three samples for which ground height and/or ground age data were either not available or could not be determined using the guidelines for determining height and age outlined in section 5.7.1. These samples were reviewed and heights and ages for the analysis were determined[14] as follows:

---

[10] Coded as VT in the BC Land Classification System.

[11] The inventory data were provided by Gary Johansen on June 22, 1999 in a file called sc170v3.dbf. A file called screp_v3.dbf contained the data for the replacement samples (dated June 29, 1999).

[12] This file, called ALLDSC_documentation.xls was provided by Craig Robinson on June 29, 1999.

[13] The compiled ground data was provided by Alf Kivari on October 13 and 15, 1999 in files called "DSC1 cluster summary NVAF 4.xls", "DSC2 cluster summary NVAF 4.xls", "DSC1 cluster x spp summary NVAF 4.xls" and "DSC2 cluster x spp summary NVAF 4.xls".

[14] The sample card data was reviewed by Laurence Bowdige and Keith Tudor. Details of their rationale for determining heights and ages for these samples are on file.

- For sample DSC2-0045, there was no species composition available even at the 4cm+ dbh utilization level. As a result, leading species for ground height and age could not readily be determined. For this sample, the small tree fixed area plot was used to identify the leading species.
- For sample DSC1-0064, no heights and ages appeared in the compiled data. After examination of the field cards, ground height and age were assigned.
- For sample DSC2-0073, there was no height or age data for either the leading or second species at any utilization. The cluster average height and age were used for this sample.

5.5 Weighting

The original population is often pre-stratified before sample selection to achieve efficiency or to improve estimation precision. In the Sunshine Coast TSA, the stakeholders determined that 80% of the samples should be established in areas identified as operable. The proportion of samples allocated to the operable and inoperable differed from the relative area they represented in the TSA. To account for the different sample selection probabilities in the operable versus inoperable strata, the samples required weights.

When the data was post-stratified for analysis (based on leading species), each strata comprised a mixture of operable and inoperable samples. Hence weights were required throughout the analysis, for reporting both strata and overall statistics.

The weights reported in Table 1 are for the population of VT polygons in the Sunshine Coast TSA[15].

Table 1: Areas and weights for strata within population of interest.

	Population		Sample			
Stratum	Area (ha)	%	# of clusters[16] = n	%	Weight = area/n	Relative weight
Operable	339,120.28	59.7	87	78.4	3897.93	1
Inoperable	229,084.92	40.3	24	21.6	9545.21	2.449
total	568,205.20	100%	111	100%		

[15] If the population of interest is changed, the areas and sample sizes, and hence weights, will also change.

[16] In this document, clusters are usually referred to as "samples".

5.6 Post-stratification

The sample data used in the Sunshine Coast VRI analysis was post-stratified in an effort to provide more precise adjustment for specific forest types within the population of interest.

The strata were determined based on a number of criteria including:

- Similar relationships in the ratios between the ground attribute values and the inventory values;
- Natural biological groupings;
- TSR analysis units;
- Number of samples available.

Using these criteria, the project team identified three strata, defined primarily by the leading species indicated by the inventory. The composition of these strata and the number of samples that comprised each is shown in Table 2 below.

Table 2: Sunshine Coast VRI strata and sample distribution among strata.

Strata composition (based on inventory attributes)	*Number of samples*
Deciduous leading	12
Douglas-fir or lodgepole pine leading	40
Cedar, hemlock or balsam leading	59
Total	111

5.7 Attributes to be adjusted

5.7.1 Age and height

Adjustments for inventory age and inventory height were developed in each stratum. The adjustments used the ratio-of-means approach. The ratio for age was calculated as:

$$\text{Ratio} = \frac{\textit{weighted mean ground age}}{\textit{weighted mean inventory age}}$$

where weighted mean ground age is the weighted mean VRI Phase II age for the samples in a stratum and weighted mean inventory age is the weighted mean projected map label age for the samples in a stratum[17]. The ratio for height was calculated in a similar manner.

[17] In this analysis of the Sunshine Coast VRI data, all operable samples carried a weight of 1 and all inoperable samples had a weight of 2.449 (see Table 1 for how the weights were determined).

A number of different ages and heights were available in the compilation of the ground data. After considerable discussion and consultation[18], the following definition for ground age and height was developed:

> Ground height is average height of T,L,S trees[19] for the leading species at 17.5 cm+ utilization (from the "species within cluster" summary compilation file). If the total basal area/ha (from cluster summary compilation file) at the 17.5 cm+ utilization did not represented at least 50% of the total basal area/ha at 4cm + dbh, the utilization was relaxed (lowered) until the total basal area/ha met this criterion. If average height was not available for the leading species at this utilization, average height for the second species at this utilization was used, so long as the leading and second species were either both coniferous or both deciduous. If average height was not available for either the leading or second species, the utilization was relaxed and the leading species was reassessed. Ground age was determined in the same manner.

There were a small number of samples for which this rule provided ambiguous results. In these cases, the project team made recommendations for appropriate ground heights and /or ages on a case-by-case basis. The details of these special cases are provided in section 5.4.

5.7.2 Volume

The adjustment for volume was developed using the same two-step process defined in the Fraser Protocol. First, the inventory age and height were adjusted for each sample polygon. These adjusted attribute values were then used as input for VDYP[20] to predict an "attribute-adjusted" inventory volume. Next, ratio-of-means adjustment factors were computed in each stratum based on a ratio of the weighted mean compiled ground volume to the weighted mean "attribute-adjusted" inventory volume for the samples in a stratum.

All ground and the inventory volumes reported in this analysis were net decay, waste and breakage. The ground volumes reported here were for live trees only and for stems with 17.5 cm+ dbh. Compiled volumes incorporated the Net Volume Adjustment Factors (NVAF).

5.8 Adjustment methodology

The ratio-of-means estimator was used as the methodology for adjusting the inventory attribute values. This is consistent with the approach used to adjust the inventory for TSR

---

[18] The definition for ground age and height for adjustment purposes was developed in a series of meetings in the early fall of 1999, by RIB staff and consultants.

[19] T trees are "top height" trees (largest DBH in 0.01 ha plot, regardless of species); L trees are "leading species" trees (largest DBH in 0.01 ha plot, of leading species by basal area based on tree count); S trees are "leading species" trees (largest DBH in 0.01 ha plot, of second species by basal area based on tree count).

[20] VDYP version 6.4a was used in this analysis.

purposes in the Fraser TSA and the Queen Charlotte Islands TSA. The ratio-of-means methodology has also been used in other VRI analysis projects[21].

In general, the adjustment methodology should be unbiased and easy to apply in the TSR analysis context. Adjustment methodologies that produce non-zero intercepts must be viewed with caution since negative attribute values or (in the case of a positive intercept) minimum non-zero attribute values could have serious implications in a timber supply context.

5.9 Limitations of the adjustment methodology

Ratio-of-means is generally appropriate if the relationship between y (ground attribute, in this case) and x (inventory attribute) is linear and passes through the origin. In some strata, this was not the case and a pattern of bias was observed in the residuals (see section 7.2.3).

Alternative regression methodologies such as least squares regression and geometric mean regression typically have non-zero intercept values unless they are conditioned to go through the origin. In cases where the y:x relationships do not appear to go through the origin, the regression methodologies often result in either a very shallow slope (for positive intercept values) or a very steep slope (for negative intercept values). Such functions may lead to large adjustment errors when applied to polygons outside of the range of the sample data.

Non-linear regression adjustment methodologies that go through the origin can be readily fit to the sample data. Although potential problems with non-zero intercepts can be avoided with these methodologies, the non-linear regression functions typically still face the same prediction issues for polygons beyond the highest range of the sample data as do other linear least squares regression methodologies.

Further study of the implications of alternative adjustment methodologies is required.

5.10 Ecological and other timber attributes for which summary statistics will be generated

Resources Inventory Branch is currently developing methodology to summarize and report on the ecological data that was collected. See Appendix A-3 for a list of reports that are currently available which summarize ecological and other timber attributes.

6 Discussion of results

6.1 Descriptive sample statistics (before adjustment)

Scatter plots showing the relationships between ground attributes and inventory attributes (age and height) are provided in Appendix A-4. The relationships between ground volume and "attribute-adjusted" volume are shown in Appendix A-5.

Mean values and confidence intervals for ground attributes and unadjusted inventory attributes are shown in Tables 3 and 4.

[21] Draft analyses based using ratio-of-means as the adjustment model have been prepared for the Dawson Creek, Lillooet and Williams Lake districts.

Table 3: Descriptive statistics for ***ground*** sample attributes, by strata.

Strata	n	Weighted mean *ground* attributes and 95% confidence intervals		
		Height (m)	Age (yrs)	Volume/ha 17.5cm+dbh, net dwb
Deciduous	12	28.4 21.8 – 35.1	47 34 – 61	322 182 – 462
Dfir-Pl	40	27.3 23.6 – 30.9	104 80 – 129	381 289 – 473
Cedar-Hem-Bal	59	23.4 21.2 – 25.6	167 137 – 196	381 315 – 448
Overall	111	25.2 23.3 – 27.0	135 115 – 155	376 326 – 427

Table 4: Descriptive statistics for ***unadjusted inventory*** sample attributes, by strata.

Strata	n	Weighted mean *unadjusted inventory* attributes and 95% confidence intervals		
		Height (m)	Age (yrs)	Volume/ha 17.5cm+dbh, net dwb
Deciduous	12	24.9 20.6 – 29.2	65 49 – 82	277 176 – 378
Dfir-Pl	40	24.7 21.6 – 27.7	93 73 – 113	320 252 – 388
Cedar-Hem-Bal	59	24.1 21.5 – 26.8	180 154 – 206	345 283 – 408
Overall	111	24.4 22.5 – 26.2	141 123 – 159	331 288 – 374

6.2 Adjustment coefficients and associated statistics

6.2.1 Height and age adjustment

Ratio-of-means adjustment factors were developed for inventory height and age in each stratum. These are shown in Tables 5 and 6 that follow. Correlation coefficients are also provided in these tables as a measure of the strength of the linear relationship between the audit and the inventory heights or ages.

Inventory height was, on average, underestimated in the deciduous, Douglas-fir and lodgepole pine leading strata when compared with the ground heights. This underestimation ranged between 10 and 14%, on average. For cedar, hemlock and balsam stands the VRI sample indicated that heights were overestimated by 3%, on average.

The analysis indicated that age in the Douglas-fir and lodgepole pine leading stratum was underestimated by about 12%, on average. In cedar, hemlock and balsam stands, inventory age was, on average, slightly overestimated. Sample in the decidous leading stratum indicated that inventory age was overestimated by about 27% on average.

Table 5: Height adjustment factors (ratio of means), by strata.

Strata[22]	*n*	Height adjustment: Ratio of weighted means (weight = 1 for operable samples & 2.449 for inoperable samples)			
		Wt'd mean ground height	Wt'd mean inventory height	Wt'd correlation	Ratio of wt'd means Adjustment factor
Deciduous	12	28.433	24.892	0.512	1.142
Dfir-Pl	40	27.253	24.664	0.777	1.105
Cedar-Hem-Bal	59	23.422	24.137	0.505	0.970
Overall	111	25.152	24.380	0.592	1.032

Table 6: Age adjustment factors (ratio of means), by strata.

Strata	*n*	Age adjustment: Ratio of weighted means (weight = 1 for operable samples & 2.449 for inoperable samples)			
		Wt'd mean ground age	Wt'd mean inventory age	Wt'd correlation	Ratio of wt'd means Adjustment factor
Deciduous	12	47.467	65.333	0.729	0.727
Dfir-Pl	40	104.373	93.231	0.637	1.120
Cedar-Hem-Bal	59	166.549	179.855	0.577	0.926
Overall	111	135.359	140.631	0.637	0.963

6.2.2 Volume adjustment

The adjustment factors for volume were derived for each stratum in a two-step process:

1. The adjustment factors in Tables 5 and 6 respectively were applied to the inventory heights and ages for the samples. Using these adjusted attribute values, inventory volumes for the samples were generated in VDYP. The volumes produced in this step are referred to as "attribute-adjusted" inventory volumes.
2. Adjustment factors for volume – ratios between the ground volume and the "attribute-adjusted" volume – were then calculated.

[22] The strata are determined from the leading species indicated by the inventory (i.e. map label).

There are two important issues to note when applying the volume adjustment factors to the inventory file:

1. The volume adjustment factors must be applied to the "attribute-adjusted" inventory volumes, that is, the VDYP volumes obtained based on adjusted heights and ages.
2. The resulting adjusted inventory volumes will reflect the utilization for the ground volumes used to derive the volume adjustment factor.

The volume adjustment factors (ratio-of-means) that were developed are provided in Table 7.

Note that for each of the proposed height, age and volume adjustments, the adjusted values of the attribute were compared with the ground values in each stratum. The difference between the ground value and the adjusted value is called a residual value and can be used in the statistical evaluation of the adjustment. A complete analysis of the residual values associated with the age, height and volume adjustments was completed and the results of this analysis are provided in Appendices A-6 and A-7.

Table 7: Volume adjustment factors (ratio of weighted means) based on NVAF[23] volumes, overall and by strata. Utilization at 17.5cm+ dbh net dwb.

Strata	*n*	Volume adjustment: Ratio of weighted means (weight = 1 for operable samples & 2.449 for inoperable samples)			
		Wt'd mean ground volume/ha	Wt'd mean "attribute-adjusted" inventory volume/ha	Wt'd correlation	Ratio of wt'd means Adjustment factor
Deciduous	12	321.681	311.650	0.714	1.032
Dfir-Pl	40	381.346	379.771	0.816	1.004
Cedar-Hem-Bal	59	381.449	331.568	0.503	1.150
Overall	111	376.494	346.509	0.622	1.087

6.3 Evaluation of the results based on target sampling errors

The original ground sampling plan specified a target sampling error of 10% for the vegetated, treed portion of the district.

To provide an indication of the sampling error achieved in the adjustment process, a comparison of the mean ground volumes and the mean unadjusted inventory volumes were made. As shown in Table 8 below, the overall sampling error achieved for the Sunshine Coast TSA was about 11.5%.

[23] Adjusted volumes will be for 17.5 cm+ dbh, net dwb using NVAF.

Table 8: Comparison of overall ground volume and unadjusted inventory volume *(volumes at 17.5cm+ dbh utilization net dwb).*

Mean volumes/ha, ratio and 95% confidence interval for ratio[24]					
n	Ground volume/ha	Unadjusted inventory volume/ha	Ratio of means	95% CI for ratio	Sampling error (as % of ratio)
111	376.494	331.062	1.137	1.01 – 1.27	11.5%

The sampling errors achieved were above the target levels that the district expected to achieve. The stakeholders need to review this sampling error result, in consideration of their current business needs, and decide if additional sampling is required.

7 Comparison of NVAF and loss factor volumes

The volume adjustment for the Sunshine Coast in this analysis was based on compiled volumes generated using the new net volume adjustment factors in this unit. Table 9 provides a comparison of the impact of ground volumes compiled with loss factors versus net volume adjustment factors.

Table 9: Comparison of ground volumes compiled with loss factors and with NVAF.

Strata	*n*	Impact of NVAF (volumes are for 17.5cm+ utilization net dwb) *(weight = 1 for operable samples & 2.449 for inoperable samples)*		
		Wt'd mean loss factor ground volume/ha	Wt'd mean NVAF ground volume/ha	Difference (NVAF – loss factor) expressed as % of loss factor volume/ha
Deciduous	12	326.054	321.681	-1.3%
Dfir-Pl	40	381.934	381.346	-0.2%
Cedar-Hem-Bal	59	370.534	381.449	+2.9%
Overall	111	370.794	376.494	+1.5%

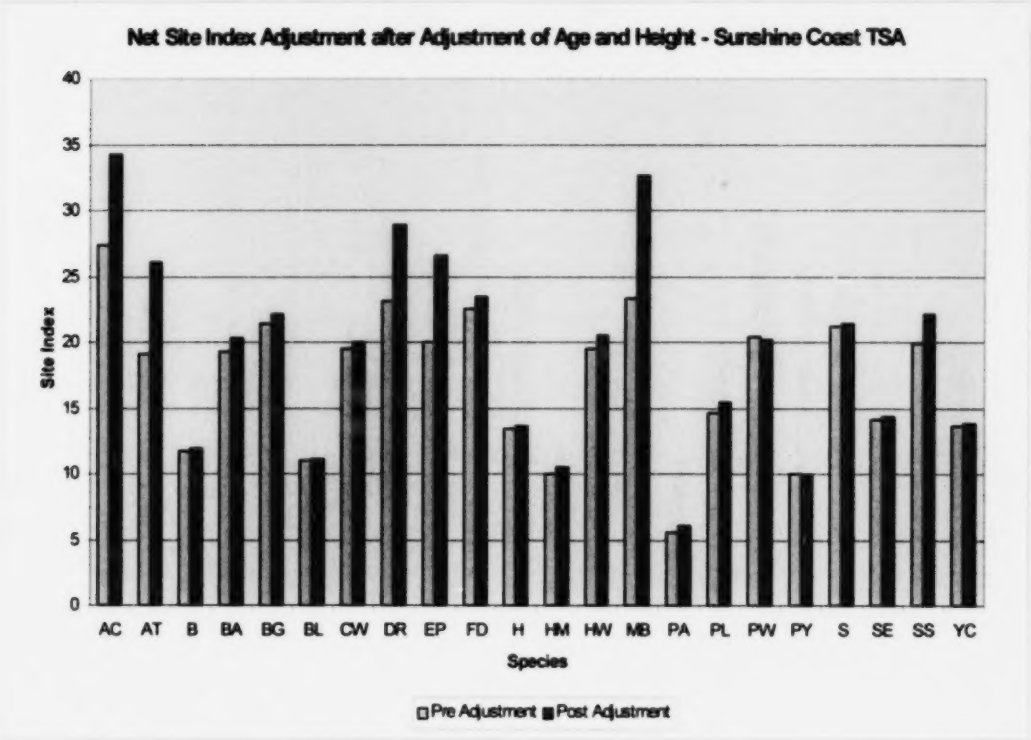
8 Application of results for TSR

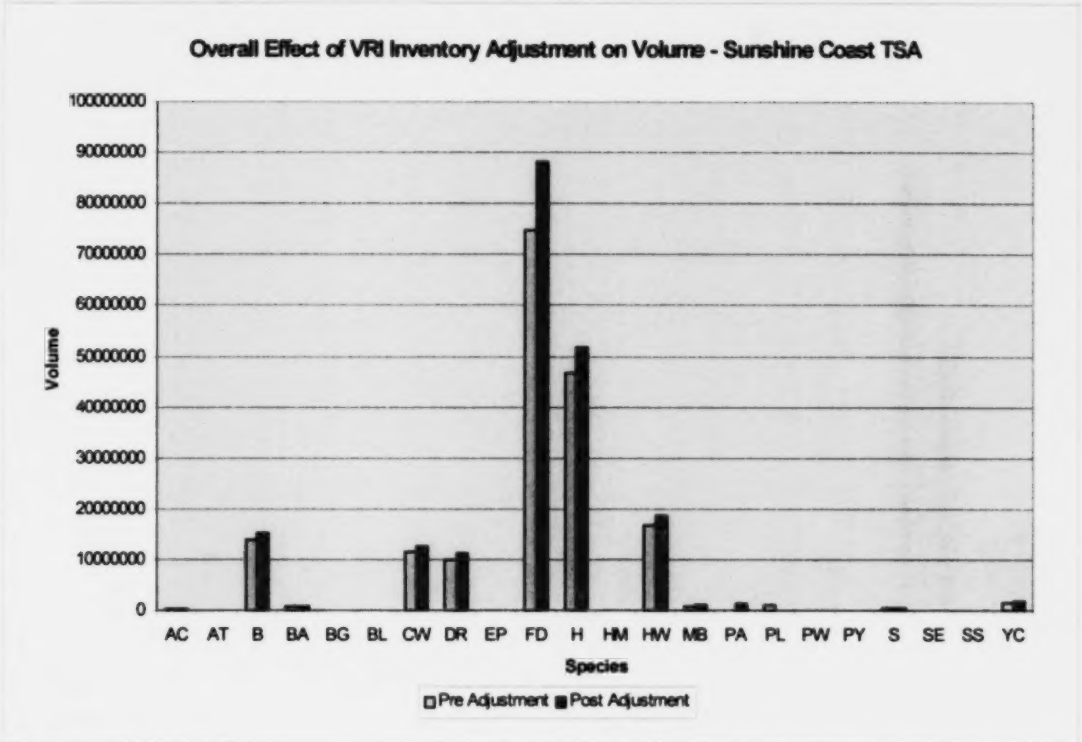
The results of this analysis were used to adjust the TSR file for TSR II. The impact of the age, height and volume adjustment on the TSA are compared below, showing the changes to site index, pre- and post-adjustment, as well as the overall change to merchantable volume. Most stands that are conifer leading, show a net increase in site

[24] The ratio is based on weighted mean volumes. The sampling error is computed by applying the appropriate relative weight to the individual samples. Using this methodology the sample size, n, effectively becomes the sum of the weights or 145.77 in this case.

index of around 1m or less. Deciduous leading stands showed a more significant increase in site index of 6-7m.

The overall impact on volume is shown below, where the bulk of the inventory adjustment is in fir leading and hemlock leading stands. The overall change in volume is an increase of 14% overall, with the most significant change occurring in fir leading stands, with an increase of over 18%.





9 Appendices

A-1 Details of sample establishment

Project	Sample	MAP_NO	POLY	NV	DONE	QA	Comments
DSC1	1	92K037	277		97		
DSC1	2	92J011	82		98-08-12		
DSC1	3	92J031	5		97		DROPPED - Danger
DSC1	4	92J082	2		97		ZERO VEG
DSC1	5	92G084	83		98-08-07		
DSC1	6	92N007	28		97		DROPPED - Danger
DSC1	7	92N008	12		97		ZERO VEG
DSC1	8	92N014	1		97		ZERO VEG
DSC1	9	92N016	10		97		ZERO VEG
DSC1	10	92N018	1		97		ZERO VEG
DSC1	11	92N024	8		97		ZERO VEG
DSC1	12	92K028	48		97		
DSC1	13	92K097	22		97		ZERO VEG
DSC1	14	92K099	73		97		ZERO VEG
DSC1	15	92N005	1		97		DROPPED - Danger - no match
DSC1	16	92K088	1		98-09-18		
DSC1	17	92K090	1		98-08-19		
DSC1	18	92K095	1		98		DROPPED - Danger - no match
DSC1	19	92K068	3		97		
DSC1	20	92K078	1		97		ZERO VEG
DSC1	21	92K085	197		98-08-26		
DSC1	22	92K040	2		97		DROPPED - Danger - no match
DSC1	23	92K049	19		97		
DSC1	24	92K059	109		97		DROPPED - Danger - no match
DSC1	25	92K090	2		97		ZERO VEG
DSC1	26	92K080	2		97		ZERO VEG
DSC1	27	92K068	3		97	X	
DSC1	28	92J061	17		98-08-17		ZERO VEG
DSC1	29	92K010	10026		97		

Project	Sample	MAP_NO	POLY	NV	DONE	QA	Comments
DSC1	30	92G082	496		97		DROPPED – Danger – no match
DSC1	31	92K019	10029		97		ZERO VEG
DSC1	32	92K079	5		98-08-17		
DSC1	33	92G071	839	YES	98	X	
DSC1	34	92G063	199	YES	98-08-12	X	
DSC1	35	92F059	200		97		
DSC1	36	92K007	59		98-09-18		
DSC1	37	92F100	10002	YES	98		
DSC1	38	92K018	10002		97		DROPPED – Danger – no match
DSC1	39	92J011	337	YES	98-08-06		
DSC1	40	92G091	161		98		DROPPED – Danger
DSC1	41	92K016	438	YES	98-09-15		
DSC1	42	92G053	729		97		
DSC1	43	92J002	294		97		
DSC1	44	92K047	195		98	X	
DSC1	45	92K088	208	YES	98-08-21		
DSC1	46	92G052	216		97		
DSC1	47	92K026	263		97		
DSC1	48	92K095	11		98-08-19		
DSC1	49	92G051	636	YES	98-08-06		
DSC1	50	92K056	335	YES	98-09-04		
DSC1	51	92K096	36	YES	98-08-21		
DSC1	52	92K037	387		98		
DSC1	53	92K025	149	YES			Private land – denied access
	53	92K025	506	YES	98-10-19		Relocated to TSA
DSC1	54	92N016	243		98-08-22		
DSC1	55	92N026	162		98-08-20		
DSC1	56	92N019	2	YES	98		DROPPED – Danger
DSC1	57	92K076	316		98-08-23		

Project	Sample	MAP_NO	POLY	NV	DONE	QA	Comments
DSC1	58	92G042	170		97		
DSC1	59	92K028	186		97		DROPPED – Danger
DSC1	60	92K058	483	YES	98-08-24		
DSC1	61	92F099	3340		97		
DSC1	62	92K020	6399	YES	98-09-03		
DSC1	63	92G052	176		97		
DSC1	64	92G062	227	YES	98		
DSC1	65	92F080	175		97		
DSC1	66	92K039	1183	YES	98		No trees
DSC1	67	92F068	218	YES			Private land – denied access
	67	92F068	218	YES	98-09-02	X	Relocated to TSA (same polygon)
DSC1	68	92K070	556	YES	98-08-25		
DSC1	69	92F098	1005				DROPPED – Danger
	69	92F098	1005		98-09-09		Relocated within same polygon
DSC1	70	92K038	352		98		DROPPED – Danger
DSC2	1	92G061	258		98-08-10	X	
DSC2	2	92G073	770		98-09-02		
DSC2	3	92K026	530		98-09-23		
DSC2	4	92K096	1036		98-08-25		
DSC2	5	92G042	327		98-09-25		
DSC2	6	92K096	105		98-08-21		
DSC2	7	92G061	521		98-09-04		
DSC2	8	92G051	2		98-08-10		
DSC2	9	92F069	50		98-09-07		
DSC2	10	92F097	507				Private – denied access
	10	92F098	342		98-11-25		Relocated to TSA
DSC2	11	92G081	218		98-08-07		
DSC2	12	92K036	33		98-09-16		

Project	Sample	MAP_NO	POLY	NV	DONE	QA	Comments
DSC2	13	92G092	97		98-08-09		
DSC2	14	92G071	896		98-08-10		
DSC2	15	92G061	535		98-09-04		
DSC2	16	92K016	266		98-09-23		
DSC2	17	92G062	295		98-09-03		
DSC2	18	92F097	249		98-08-13		
DSC2	19	92G073	92		98-09-02		
DSC2	20	92J002	11		98-08-08		DROPPED – Danger
DSC2	21	92F069	113		98-09-02		
DSC2	22	92G073	192		98-09-03		
DSC2	23	92G081	8		98-08-11		
DSC2	24	92J002	560		98-08-08		
DSC2	25	92K037	333		98-09-20		
DSC2	26	92K017	574		98-09-18		
DSC2	27	92G062	819		98-09-07		
DSC2	28	92K037	69		98-09-19		
DSC2	29	92F059	272		98-09-05		
DSC2	30	92K055	340		98-08-26		
DSC2	31	92F088	193		98-08-06		
DSC2	32	92G081	174		98-08-20		DROPPED – Danger
DSC2	33	92G053	456		98-08-13		DROPPED – Danger
DSC2	34	92K086	11		98-08-19		DROPPED – Danger
DSC2	35	92N005	65		98-08-20		
DSC2	36	92K100	23		98-08-23	X	
DSC2	37	92G092	8		98-08-13		
DSC2	38	92G052	697		98-09-28		
DSC2	39	92K055	479		98-09-22		
DSC2	40	92K027	474		98-08-19		DROPPED – Danger

Project	Sample	MAP_NO	POLY	NV	DONE	QA	Comments
DSC2	41	92K037	489		98-09-19		
DSC2	42	92K025	255		98-09-20		
DSC2	43	92K086	90		98-08-19		
DSC2	44	92F078	457				Private – denied access
	44	92F088	11		98-11-26		Relocated to MB private land
DSC2	45	92K076	508		98-08-24		
DSC2	46	92F078	326		98-09-06		Private – access granted
DSC2	47	92G092	198		98-08-09	X	
DSC2	48	92G051	734		98-09-05	X	
DSC2	49	92F068	59		98-10-22		Private – access granted
DSC2	50	92G063	338		98-09-30		
DSC2	51	92K026	653		98-09-24		
DSC2	52	92G072	660		98-09-27		
DSC2	53	92G054	540		98-09-29		
DSC2	54	92F078	249		98-09-09		
DSC2	55	92F089	187		98-09-10		
DSC2	56	92F078	94		98-09-03	X	
DSC2	57	92F097	605		98-08-05		
DSC2	58	92G062	417		98-09-24		DROPPED – Danger
DSC2	59	92F050	29		98-09-09	X	
DSC2	60	92K096	287		98-09-21		
DSC2	61	92G054	193		98-09-06		
DSC2	62	92G072	345		98-08-11		
DSC2	63	92N015	446		98-08-22		
DSC2	64	92K016	301		98-09-24		
DSC2	65	92K007	800		98-09-17		
DSC2	66	92G071	369		98-09-26		
DSC2	67	92G063	683		98-09-23		

Project	Sample	MAP_NO	POLY	NV	DONE	QA	Comments
DSC2	68	92F077	68		98-11-27		Private – access granted
DSC2	69	92K035	242		98-09-16		
DSC2	70	92K059	104		98-08-24		
DSC2	71	92G043	312		98-12-01		
DSC2	72	92K066	114		98-08-27		
DSC2	73	92K010	172		98-08-11		
DSC2	74	92G053	693		98-08-13		
DSC2	75	92K066	143		98-09-21		
DSC2	76	92K086	334		98-08-19		DROPPED – Danger
DSC2	77	92G063	276				Inaccessible – snow depth (treed)
DSC2	78	92K056	136		98-09-22		
DSC2	79	92J001	221		98-08-12		
DSC2	80	92K017	330		98-10-02		
DSC2	81	92F049	22		98-09-11		Not sampled
DSC2	82	92K025	589				Private – no contact
DSC2	83	92G082	633				Not sampled
DSC2	84	92K038	31		98-10-03		
DSC2	85	92F088	11		98-08-05		
DSC2	86	92F089	110		98-08-07	X	
DSC2	87	92F098	257				Not sampled
DSC2	88	92K077	501		98-08-23		
DSC2	89	92G043	137		98-09-05		
DSC2	90	92G052	902		98-09-06		
DSC2	91	92K086	205		98-08-25		
DSC2	92	92G052	858		98-08-09		
DSC2	93	92K007	353				Not sampled
DSC2	94	92G072	375		98-08-11	X	
DSC2	95	92G081	62				Not sampled
DSC2	96	92K056	301		98-08-27		

Project	Sample	MAP_NO	POLY	NV	DONE	QA	Comments
DSC2	97	92K087	329		98-08-21	X	
DSC2	98	92G053	328		98-12-18		No eco data - snow depth (treed)
DSC2	99	92N016	44		98-08-22	X	
DSC2	100	92G052	645				Private - denied access
	100	92G052	645		98-11-20	X	Relocated to TSA (same polygon)
DSC2	101	92K006	143				Not sampled
DSC2	102	92G053	423		98-11-28		
DSC2	103	92F098	510		98-08-07		
DSC2	104	92G043	243				Private - access denied - no match
DSC2	105	92F088	354		98-08-06		
DSC2	106	92G082	862		98-11-29		
DSC2	107	92K028	180				Not sampled
DSC2	108	92K028	81		98-09-17	X	
DSC2	109	92G061	324				Not sampled
DSC2	110	92G052	541		98-08-09		
DSC2	111	92K016	11				Not sampled
DSC2	112	92G072	70		98-11-30		
DSC2	113	92K027	409				Not sampled
DSC2	114	92K065	103		98-08-26		
DSC2	115	92N005	277				Not sampled
DSC2	116	92K038	7		98-08-19		DROPPED - Danger
DSC2	117	92G083	55				Not sampled
DSC2	118	92G082	15		98-08-12		
DSC2	119	92G092	188				Not sampled
DSC2	120	92K097	185		98-08-21		

NV = NVAF Sample

Not Sampled = Not attempted, part of an additional dataset

DROPPED - Danger = Original location attempted on ground, checked by MoF (not replaced)

DROPPED - Danger - no match = Original and replacement attempted on ground without success

ZERO VEG = Rock or Ice

A-2 Details on samples examined as potential "outliers"

Sample	*Comment*
DSC1 - 0043	Poorly typed polygon. Its labelled HBYc 9517, but the sample landed in very sparse, rocky portion of the sample.
DSC1 - 0064	Sub alpine parkland. Very low density forest.
DSC2 - 0006	Polygon was logged 4 years ago, but did not reflect on map. No live trees in the sample, one dead fir.
DSC2 - 0017	no trees >17.5 cm DBH. IPC landed on a road. Patchy polygon that is poorly typed. Plot in poorer part of polygon.
DSC2 - 0018	High volume fir stand. Recurring pattern that many of the 2nd growth fir stands seem to have a much higher ground volume than the label volume.
DSC2 - 0021	A remnant stand, but appears OK.
DSC2 - 0029	Very patchy stand. Sample in a poor part of the stand. Trees are in poor condition with lots of defect. THIS IS A LAYERED STAND.
DSC2 - 0039	High elevation, patchy stand. The samples trees considerably shorter than the label height.
DSC2 - 0045	Was a young alder/maple stand that has been recently logged. Logging not on map. No trees in the sample.
DSC2 - 0078	Large, sparse polygon. The sample is in a productive corner of the polygon.
DSC2 - 0085	Very weird sample. The polygon is labelled as old alder. The IPC and 2 aux's landed in Hybrid Poplar Plantation. One aux landed in the original alder stand, and one aux on the highway. Because of the sampling procedures, the first enhanced alder was 5.1cm DBH, even though there were several very large alder in the south aux. Show a low volume. few hybrid poplar >17.5 cm DBH.
DSC2 - 0089	Looks OK. Sample was in dense part of stand.
DSC2 - 0092	Found a serious keypunching error. I notified Laurence, Bob and Alf. The volume will go down considerably.
DSC2 - 0094	Very uniform poly. Ground height much higher than label height.
DSC2 - 0118	Uniform, dense stand. Ground height 10m greater than label height.
DSC2 - 0120	Low productivity polygon. Sample looks OK. Ground height > than the map height.
DSC2 - 102	Polygon has some recent logging in it. The sample is near a boundary. Only 2 trees > 17.5cm DBH.

A-3 List of VRI reports summarizing ecological and other timber attributes

Name	Description	Status*	Active /Inactive
	Sample Data Listings - for verification of input		
LL1	location Details	Not defined	Inactive
LT1	Large Tree Summary	Draft	Active
LT2	Small Tree and Stump Data	Draft	Inactive
LT3	Top Height and Site Tree Data	Draft	Inactive
LT4	Damage Agents and Loss Indicators	Draft	Inactive
LT5	Stem Map Data	Draft	Inactive
LE1	Ecological Data	Not defined	Inactive
LR1	Range Data	Not defined	Inactive
LC1	Coarse Woody Debris	Draft	Active
	Sample Cluster Reports		
CT1	Timber Summary	Draft used since '97	Active
CE1	Ecological Summary	Not defined	Inactive
CC1	Coarse WoodyDebris Summary	Draft	Active
CR1	Range Summary	Draft	Active
	Project reports		
PS1	Sample Plot Information	Draft	Active
PT1	Tree Counts	Draft	Active
PT2	Gross/Net Volume by Species and Utilization Limit	Not Defined	Inactive
PT3	Log Grade Distribution by Species	Draft	Inactive
PT4	Piece Size Distribution by Species	Draft	Inactive
PT5	Forest Health Information	Draft	Inactive
PT6	Wildlife Tree Information	Draft	Inactive
PT7	Old Growth and Succession Information	Not defined	Inactive
PE1	Ecological Information	Not defined	Inactive
PC1	Coarse Woody Debris Information (6 part report)	Draft	Active
PR1	Range Information	Draft	Active
PB1	Woody Biomass Volumes	Not defined	Inactive
PT8	Quality Assurance Report	Approved	Active
PT9	Quality Control report	Quality Control report	Active

** Reports that indicate "draft" status can be currently produced; other reports listed are planned for future availability.*

A-4 Plots of ground height and age versus inventory height and age, by strata

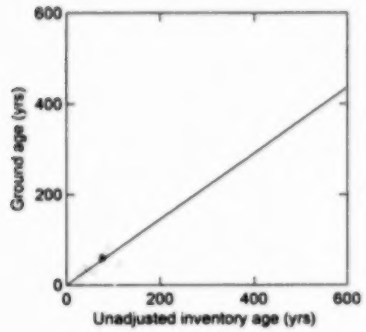


Fig. 1: DECIDUOUS SAMPLES.
Ground age versus unadjusted inventory age. The line on the graph represents the ratio of weighted means. The relative weight of each sample is indicated by its size on the scatterplot.

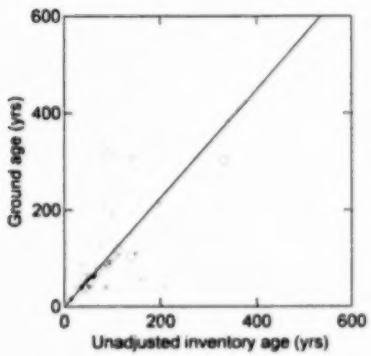


Fig. 2: DOUGLAS-FIR OR LODGEPOLE PINE SAMPLES.
Ground age versus unadjusted inventory age. The line on the graph represents the ratio of weighted means. The relative weight of each sample is indicated by its size on the scatterplot.

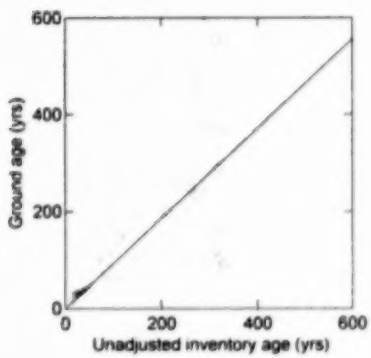


Fig. 3: HEMLOCK, BALSAM OR CEDAR SAMPLES.
Ground age versus unadjusted inventory age. The line on the graph represents the ratio of weighted means. The relative weight of each sample is indicated by its size on the scatterplot.

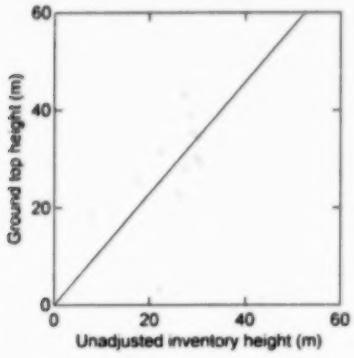


Fig. 4: DECIDUOUS SAMPLES.
Ground top height versus unadjusted inventory height. The line on the graph represents the ratio of weighted means. The relative weight of each sample is indicated by its size on the scatterplot.

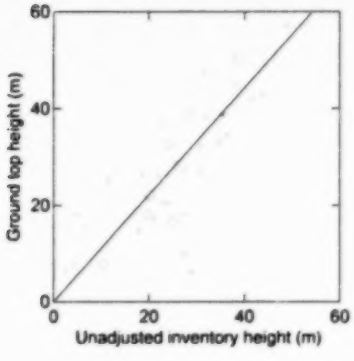


Fig. 5: DOUGLAS-FIR OR LODGEPOLE PINE SAMPLES.
Ground top height versus unadjusted inventory height. The line on the graph represents the ratio of weighted means. The relative weight of each sample is indicated by its size on the scatterplot.

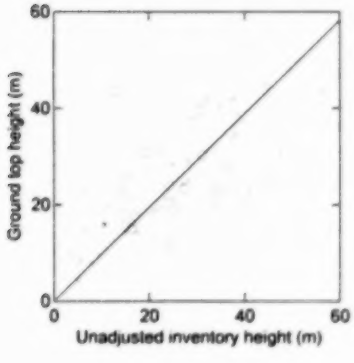


Fig. 6: HEMLOCK, BALSAM OR CEDAR SAMPLES.
Ground top height versus unadjusted inventory height. The line on the graph represents the ratio of weighted means. The relative weight of each sample is indicated by its size on the scatterplot.

A-5 Plots of ground volume versus "attribute-adjusted" inventory volume, by strata

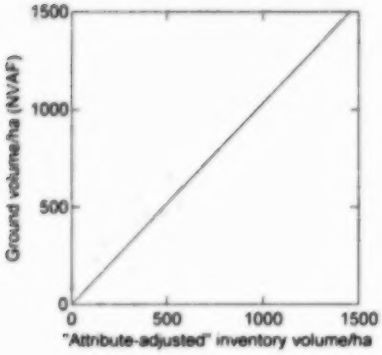


Fig. 1: DECIDUOUS SAMPLES.
Compiled volume/ha versus "attribute-adjusted" inventory volume/ha (based on ratio-adjusted heights and ages). The line on the graph represents the ratio of weighted means. The relative weight of each sample is indicated by its size on the scatterplot.

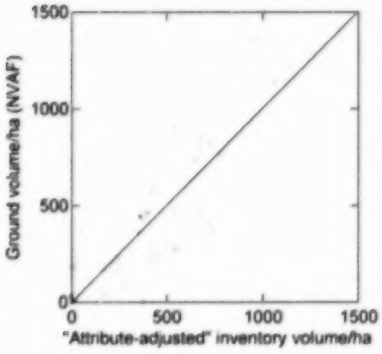


Fig. 2: DOUGLAS-FIR OR LODGEPOLE PINE SAMPLES.
Compiled volume/ha versus "attribute-adjusted" inventory volume/ha (based on ratio-adjusted heights and ages). The line on the graph represents the ratio of weighted means. The relative weight of each sample is indicated by its size on the scatterplot.

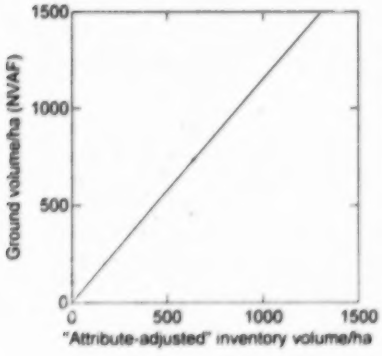


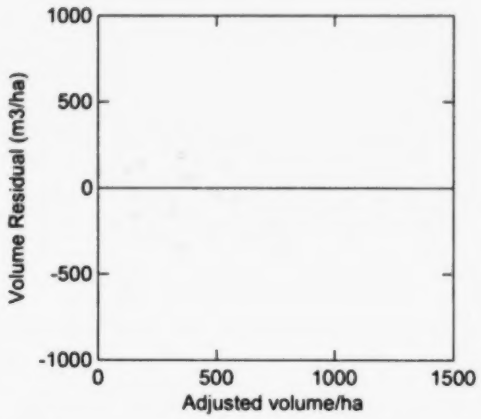
Fig. 3: HEMLOCK, BALSAM OR CEDAR SAMPLES.
Compiled volume/ha versus "attribute-adjusted" inventory volume/ha (based on ratio-adjusted heights and ages). The line on the graph represents the ratio of weighted means. The relative weight of each sample is indicated by its size on the scatterplot.

A-6 Residuals Analysis

For each of the proposed height, age and volume adjustments, the adjusted values of the attribute were compared with the ground values in each stratum. The difference between the ground value and the adjusted value is called a residual value[25]. Residual values were plotted against the adjusted values to evaluate potential bias associated with the adjustment. A complete set of the plots of residuals versus adjusted values is provided in Appendix A-10.

For most attributes and most strata, the residuals are distributed in an approximately even horizontal band across the range of adjusted values. Figure 1 below illustrates this pattern. This horizontal band of residuals indicates an unbiased fit for the ratio adjustment.

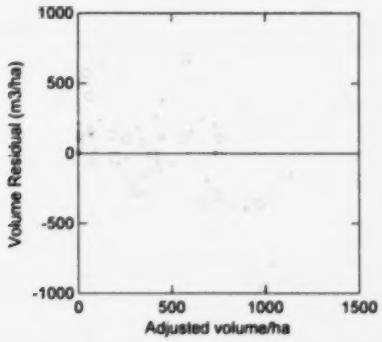
Figure 1: Plot of residual values versus adjusted volume/ha for the deciduous stratum.



However, in some strata, the pattern of residuals indicated potential bias associated with the ratio adjustment model. As can be seen in Figure 2, there is a downward sloping trend in the residuals in some strata. This indicates that the ratio adjustment tends to underestimate volume in low volume stands and overestimate volume in higher volume stands. Such a trend in the residuals means that the ratio-of-means model may not be appropriate for volume adjustment in this stratum.

[25] Residual value = ground value – adjusted value.

Figure 2: Plot of residuals values versus adjusted volume for the hemlock, balsam & cedar stratum.



To correct for this potential bias, various alternative adjustment models for volume were considered, including least squares regression (LSR), least square through the origin (LSO), geometric mean regression (GMR) and various non-linear regression models. An example of an alternative volume adjustment using GMR is shown below.

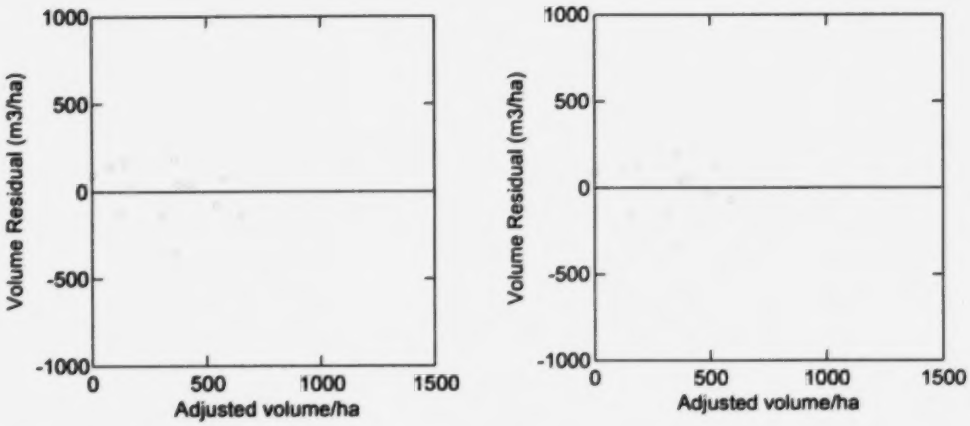
Table 1: Volume adjustment equations (NVAF)26, by strata, *using weighted GMR*. (Note: these adjustment equations are applied to inventory volumes that have been generated from *"ratio-of-means"-adjusted heights and ages*.)

Strata	*n*	Volume Adjustment: weighted GMR *(weight = 1 for operable samples & 2.449 for inoperable samples)*	
		intercept	*Slope*
Deciduous	12	-81.066	1.292
Dfir-Pl	40	-74.395	1.200
Cedar-Hem-Bal	59	18.455	1.095

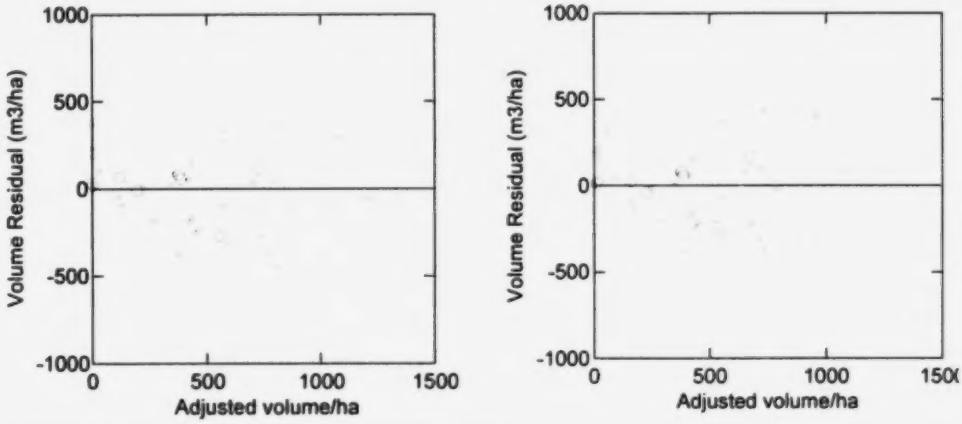
For each of the alternatives tested, the adjusted volume residuals were examined. Figure 3 provides a comparison of the GMR-adjusted volume residuals (generated from Table 1) with the ratio of means-adjusted volume residuals.

[26] Adjusted volumes are for 17.5 cm+ dbh, net dwb using NVAF.

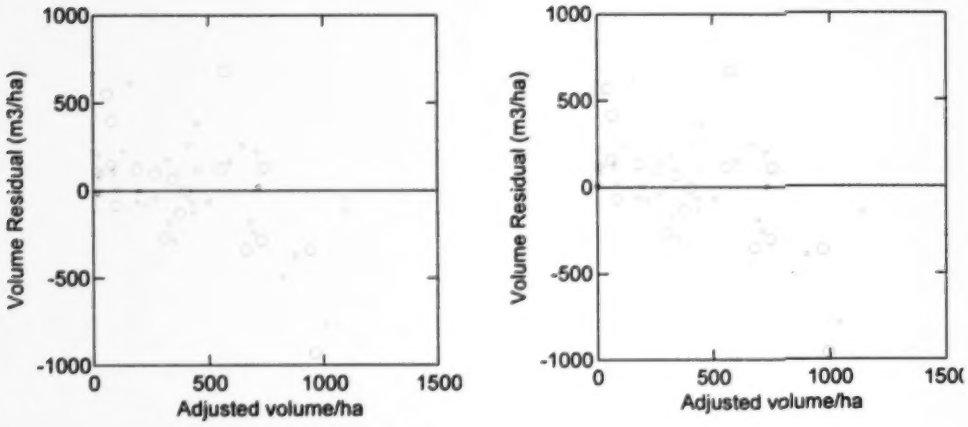
Figure 3: Adjusted volume/ha residuals plots for GMR and ratio-adjusted volume.



DECIDUOUS STRATUM:
Residuals for predicted volume/ha based on GMR-adjusted volume (LEFT) and ratio-adjusted volume (RIGHT). The relative weight of each sample is indicated by its size on the scatterplot.



DOUGLAS-FIR / LODGEPOLE PINE STRATUM:
Residuals for predicted volume/ha based on GMR-adjusted volume (LEFT) and ratio-adjusted volume (RIGHT). The relative weight of each sample is indicated by its size on the scatterplot.



BALSAM, HEMLOCK,CEDAR STRATUM:
Residuals for predicted volume/ha based on GMR-adjusted volume (LEFT) and ratio-adjusted volume (RIGHT). The relative weight of each sample is indicated by its size on the scatterplot.

The alternative adjustment approaches examined were, in general, either unable to correct the bias trend observed in the residuals or resulted in other prediction anomalies (see figure 3 comparison of residuals for GMR and ratio of means). Both the GMR and the least squares regression (LSR) approaches produced significant intercept values that could have implications if applied in the TSR context. In addition, the LSR approach resulted in very "flat" adjustment (high intercept and low slope) that greatly restricted the range of predicted values. Despite the recognized bias trend, ratio-of-means was seen as a more conservative adjustment approach. As a result, ratio-of-means was recommended for age, height and volume in all strata in this analysis. However, further study of alternative adjustment methodologies and potential implications for their usage is recommended. Note also that the potential implications for site index caused by the bias trend in the ratio-of-means height adjustment are unclear.

A-7 Residuals plots

RESIDUALS PLOTS FOR AGE

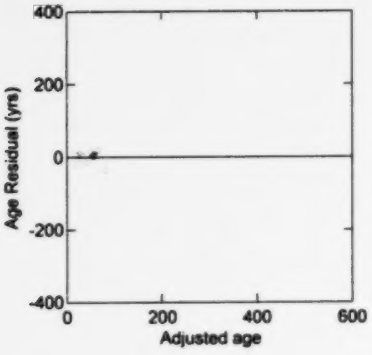


Fig. 1: DECIDUOUS SAMPLES.
Residuals for predicted age (i.e. ratio-adjusted age). The adjustment ratio is based on weighted means where the weight is operability based. The relative weight of each sample is indicated by its size on the scatterplot.

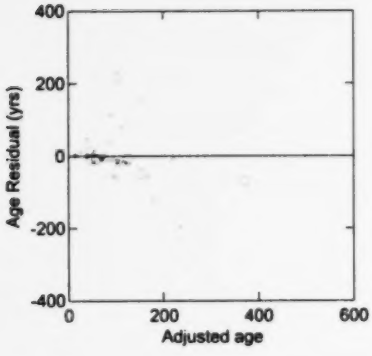


Fig. 2: DOUGLAS-FIR OR LODGEPOLE PINE SAMPLES.
Residuals for predicted age (i.e. ratio-adjusted age). The adjustment ratio is based on weighted means where the weight is operability based. The relative weight of each sample is indicated by its size on the scatterplot.

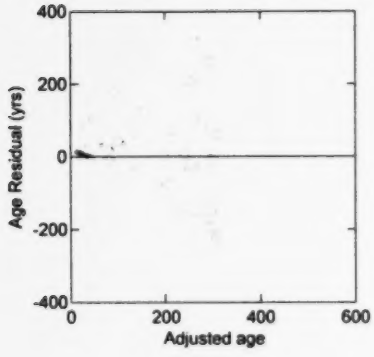


Fig. 3: HEMLOCK, BALSAM OR CEDAR SAMPLES.
Residuals for predicted age (i.e. ratio-adjusted age). The adjustment ratio is based on weighted means where the weight is operability based. The relative weight of each sample is indicated by its size on the scatterplot.

RESIDUALS PLOTS FOR HEIGHT

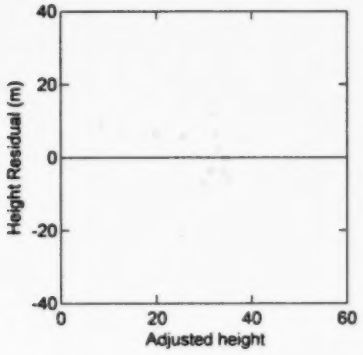


Fig. 4: DECIDUOUS SAMPLES.
Residuals for predicted height (i.e. ratio-adjusted height). The adjustment ratio is based on weighted means where the weight is operability based. The relative weight of each sample is indicated by its size on the scatterplot.

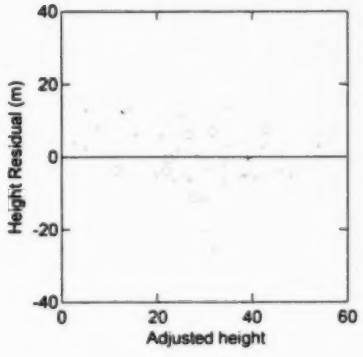


Fig. 5: DOUGLAS-FIR OR LODGEPOLE PINE SAMPLES.
Residuals for predicted height (i.e. ratio-adjusted height). The adjustment ratio is based on weighted means where the weight is operability based. The relative weight of each sample is indicated by its size on the scatterplot.

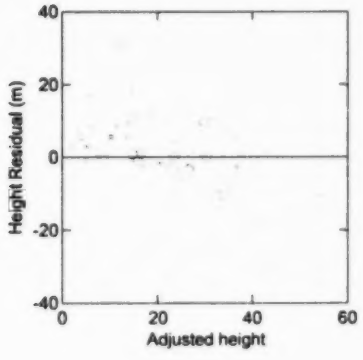


Fig. 6: HEMLOCK, BALSAM OR CEDAR SAMPLES.
Residuals for predicted height (i.e. ratio-adjusted height). The adjustment ratio is based on weighted means where the weight is operability based. The relative weight of each sample is indicated by its size on the scatterplot.

RESIDUALS PLOTS FOR VOLUME

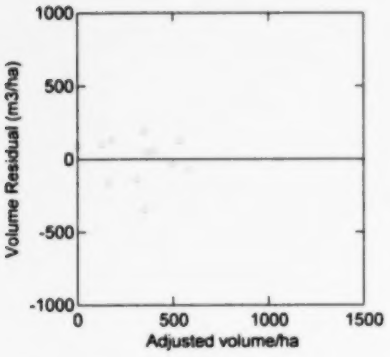


Fig. 7: DECIDUOUS SAMPLES.
Residuals for predicted volume/ha (i.e. ratio-adjusted volume). The adjustment ratio is based on weighted means where the weight is operability based. The relative weight of each sample is indicated by its size on the scatterplot.

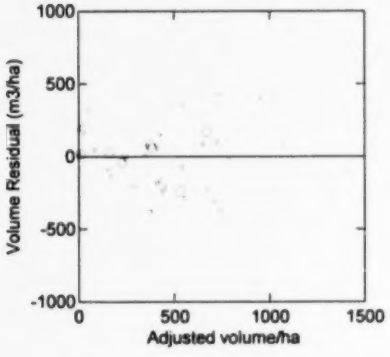


Fig. 8: DOUGLAS-FIR OR LODGEPOLE PINE SAMPLES.
Residuals for predicted volume/ha (i.e. ratio-adjusted volume). The adjustment ratio is based on weighted means where the weight is operability based. The relative weight of each sample is indicated by its size on the scatterplot.

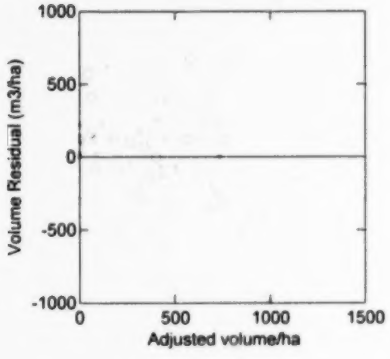


Fig. 9: HEMLOCK, BALSAM OR CEDAR SAMPLES.
Residuals for predicted volume/ha (i.e. ratio-adjusted volume). The adjustment ratio is based on weighted means where the weight is operability based. The relative weight of each sample is indicated by its size on the scatterplot.